WHAT IS CLAIMED IS:

1. A pneumatically operated active vibration damping device comprising:

a first and a second mounting member, which are spaced apart from each other;

an elastic body elastically connecting said first and second mounting members and partially defining a pressure-receiving chamber, said pressure-receiving chamber being filled with a non-compressible fluid whose pressure is changed upon application of a vibration to be damped between said first and second mounting members;

an easily deformable flexible diaphragm partially defining an equilibrium chamber on one of opposite sides thereof, said equilibrium chamber being filled with said non-compressible fluid and having a volume easily variable;

a first orifice passage for fluid communication between said pressure-receiving chamber and said equilibrium chamber;

an elastic oscillating plate partially defining said pressure-receiving chamber on one of opposite sides thereof and an oscillating air chamber on an other one of said opposite sides thereof, said elastic oscillating plate being oscillated by a periodic change of an air pressure generated in said oscillating air chamber, so as to actively generate a change of a fluid pressure in said pressure receiving chamber, for actively damping said vibration to be damped based on said change of said fluid pressure in the pressure receiving chamber, and

a static pressure control mechanism adapted to substantially statically change at least one of said fluid pressure in said pressure receiving chamber and said air pressure in said oscillating air chamber, so as to induce a substantially static elastic deformation of said elastic oscillating plate for changing a spring stiffness of said elastic oscillating plate.

2. A pneumatically operated active vibration damping device according to claim 1, wherein said oscillating air chamber is applied with said periodic change of said air pressure whose frequency is corresponding to a frequency of said vibration to be damped, while said static pressure control mechanism is operated to substantially statically change at least one of said fluid pressure in said pressure receiving chamber and said air pressure in said oscillating air chamber so as to adjust said spring stiffness of said elastic oscillating plate such that a value of a natural frequency of said elastic oscillating plate increases as a value of said frequency of said vibration to be damped increases.

3. A pneumatically operated active vibration damping device according to claim 1, wherein said static pressure control mechanism comprises a static working air chamber partially defined by and formed on an other one of opposite sides of said flexible diaphragm remote from said equilibrium chamber, said static working air chamber undergoing a static change of an air pressure therein, which is applied to said pressure receiving chamber via said flexible diaphragm, said equilibrium chamber and said first orifice passage, so as to substantially statically change said fluid pressure in said pressure receiving chamber.

4. A pneumatically operated active vibration damping device according to claim 3, further comprising a static pressure regulating switch valve operable based on a control signal applied thereto for selective connection of said static working air chamber to an external vacuum source and an atmosphere, wherein said static pressure regulating switch valve is operated to alternately connect said static working air chamber to said vacuum source and said atmosphere at a high frequency which is higher than a frequency of said vibration to be damped and which is high enough to

induce said substantially static elastic deformation of said elastic oscillating plate, and wherein a duty ratio of said control signal is adjusted according to said frequency of said vibration to be damped so that a ratio of a time of connection of said static working air chamber to said vacuum source in a switching operation of said static pressure regulating switch valve is changed, to thereby substantially statically change said spring stiffness of said elastic oscillating plate.

5. A pneumatically operated active vibration damping device according to claim 1, wherein said oscillating air chamber being applied with both of said periodic change of said air pressure for actively oscillating said elastic oscillating plate and a substantially static change of an air pressure for inducing said substantially static elastic deformation of said elastic oscillating plate.

6. A pneumatically operated active vibration damping device according to claim 3, further comprising an active pressure regulating switch valve operable based on a first control signal applied thereto for selective connection of said oscillating air chamber to an external vacuum source and an atmosphere, and an static pressure regulating switch valve operable based on a second control signal applied thereto for selective connection of said static working air chamber to said vacuum source and said atmosphere,

wherein said active pressure regulating switch valve is operated to alternately connect said oscillating air chamber to said vacuum source and said atmosphere at a frequency corresponding to a frequency of said vibration to be damped, and a duty ratio of said first control signal is adjusted according to an amplitude of said vibration to be damped so that a ratio of a time of connection of said oscillating air chamber to said vacuum source in a switching operation of said active pressure regulating switch valve is changed,

to thereby generate said periodic change of said air pressure in said oscillating air chamber, while said static pressure regulating switch valve is operated to alternately connect said static working air chamber to said vacuum source and said atmosphere at a high frequency which is higher than a frequency of said vibration to be damped and which is high enough to induce said substantially static elastic deformation of said elastic oscillating plate, and a duty ratio of said second control signal is adjusted according to said frequency of said vibration to be damped so that a ratio of a time of connection of said static working air chamber to said vacuum source in a switching operation of said static pressure regulating switch valve is changed, to thereby substantially statically change said spring stiffness of said elastic oscillating plate.

7. A pneumatically operated active vibration-damping device according to claim 1, further comprising:

a restricting member,

wherein said elastic oscillating plate is partially brought into abutting contact with said restricting member so as to increase said spring stiffness thereof, and

wherein said static pressure control mechanism is operable to induce said substantially static elastic deformation of said elastic oscillating plate so that said elastic oscillating plate is moved to be held in contact with and away from said restricting member.

8. A pneumatically operated active vibration-damping device according to claim 7, wherein said elastic oscillating plate is partially held in abutting contact with said restricting member at an initial state thereof, and said static pressure control mechanism is operable so as to induce said static elastic deformation of said elastic oscillating plate so that said elastic oscillating plate is moved away from said restricting member.

9. A pneumatically operated active vibration damping device according to claim 1, further comprising:

a partition member which is adapted to divide said pressure-receiving chamber into a primary fluid chamber partially defined by said elastic body and an auxiliary fluid chamber partially defined by said elastic oscillating plate; and

a second orifice passage for fluid communication between said primary fluid chamber and said auxiliary fluid chamber, wherein said elastic oscillating plate being oscillated so as to actively generate a pressure change of the fluid in said auxiliary fluid chamber, which is transmitted to said primary fluid chamber via said second orifice passage.

10. A pneumatically operated active vibration damping device according to claim 9, wherein said elastic oscillating plate is fluid-tightly fixed at an peripheral portion thereof to said partition member so that said auxiliary fluid chamber is defined by and between said elastic oscillating plate and said partition member, and said second orifice passage is disposed radially outwardly of said peripheral portion of said elastic oscillating plate.

11. A pneumatically operated active vibration damping device according to claim 9, wherein said device is applied as an engine mount for an automotive vehicle, and

wherein said first orifice passage is tuned to a low frequency band corresponding to engine shakes, and said second orifice passage is tuned to a high frequency band corresponding to engine idling vibrations and booming noises.

12. A pneumatically operated active vibration damping

device according to claim 11, wherein said static pressure control mechanism is operable to change said spring stiffness of said elastic oscillating plate so that said second orifice passage is selectively tuned to a first frequency band corresponding to said engine idling vibrations and a second frequency band corresponding to said booming noises.

13. A pneumatically operated active vibration damping device according to claim 11, wherein said static pressure control mechanism is operable to apply a static negative pressure to said at least one of said pressure receiving chamber and said oscillating air chamber so that said elastic oscillating plate is elastically deformed in order to reduce said spring stiffness thereof.

14. A pneumatically operated active vibration damping device according to claim 1, further comprising:

an active pressure regulating switch valve which is operable for selectively connect said oscillating air chamber to a vacuum source and an atmosphere,

wherein said active pressure regulating switch valve is operated to alternately connect said oscillating air chamber to said vacuum source and said atmosphere at a frequency corresponding to a frequency of said vibration to be damped, and

wherein a switching operation of said active pressure regulating switch valve is controlled according to a first control signal whose duty ratio is adjusted according to said vibration to be damped so that a ratio of a time of connection of said oscillating air chamber to said vacuum source is adjusted so as to apply said periodic change of said air pressure to said oscillating air chamber to thereby oscillate said elastic oscillating plate corresponding to said vibration to be damped.

15. A pneumatically operated active vibration damping device according to claim 14, wherein said device is applied as an engine mount, and

wherein said first control signal applied to said active pressure regulating switch valve has a frequency substantially equal to that of an engine ignition pulse signal, and a phase of said first control signal with respect to said engine ignition pulse signal is adjusted according to an engine speed.

16. A pneumatically operated active vibration damping device according to claim 1, wherein said second mounting member has a cylindrical cup shape and is open to said first mounting member with a spacing therebetween, such that an open end portion of said second mounting member is fluid-tightly closed by said elastic body interposed between and elastically connecting said first and second mounting members,

wherein said second mounting member supports a partition structure press-fitted into a cylindrical interior portion thereof, said partition structure cooperating with said elastic body to form said pressure receiving chamber on one of opposite sides thereof, and including an integrally formed restricting member adapted to support said elastic oscillating plate and cooperate with said elastic oscillating plate to form therebetween said oscillating air chamber, and

wherein said second mounting member supports said flexible diaphragm so as to be located between said partition structure and a bottom surface of said second mounting member, said flexible diaphragm cooperating with said partition structure to form said equilibrium chamber on one of opposite sides thereof, while cooperating with said bottom surface to form a fluid tightly enclosed static working air chamber on an other one of said opposite sides thereof, said static working air chamber undergoing a static change of an air pressure therein, which is applied to said pressure

receiving chamber via said flexible diaphragm, said equilibrium chamber and said first orifice passage, so as to substantially statically change said fluid pressure in said pressure receiving chamber.

17. A pneumatically operated active vibration damping device according to claim 16, wherein said partition structure serves for defining said first orifice passage at an outer circumferential portion thereof.

18. A pneumatically operated active vibration damping device according to claim 16, wherein said partition structure has a pressure transmitting passage, which is open at one of opposite ends thereof to said oscillating air chamber defined between said integrally formed restricting member thereof and the elastic oscillating plate and at an other one of said opposite ends thereof in an port connectable to an external air source.

19. A pneumatically operated active vibration damping device according to claim 3, wherein said device is applied as an engine mount for an automotive vehicle, said device further comprising:

a first and a second air conduits connected to said oscillating air chamber and said static working air chamber, respectively;

an active pressure regulating switch valve which is connected to said first air conduit and which is operable for selective connection of said oscillating air chamber to an external vacuum source and an atmosphere;

a static pressure regulating switch valve which is connected to said second air conduit and which is operable for selective connection of said static working air chamber to said vacuum source and said atmosphere; and

a controller adapted to control switching operation of said active and static pressure regulating switch valves, on the basis of said driving condition of said vehicle,

wherein said controller controls said switching operation of said

active pressure regulating switch valve such that said oscillating air chamber is alternately connected to said vacuum source and said atmosphere, at a frequency and phase corresponding to those of vibration to be damped, and

wherein said controller controls said switching operation of said static pressure regulating switch valve such that said static working air chamber is connected to said atmosphere upon a running condition of said vehicle, and to said vacuum source upon a stationary condition of said vehicle.

20. A pneumatically operated active vibration damping device according to claim 19, wherein said controller receives an engine ignition pulse signal and an engine speed signal, and applies a first control signal to said active pressure regulating switch valve, said drive signal has a frequency substantially equal to that of said engine ignition pulse signal, and a phase of said control signal with respect to said engine ignition pulse signal is adjusted according to said engine speed signal.